Naval Command,
Control and Ocean
Surveillance Center RDT&E Division San Diego, CA
92152-5000

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Hybrid Microcircuit Assembly Manufacturing Process Parameters Data List

Treese and Associates, Inc.

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San Diego, California 92152-5000

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ADMINISTRATIVE INFORMATION

This document describes a study conducted during January 1992 by Treese and Associates, Inc., 275 Orange Avenue, Goleta, California 93117, as a sub-contractor to Computer Sciences Corporation. Treese and Associates, Inc., performed the study to complete contract N66001-89-C-0061, which was sponsored by the U. S. Navy Manufacturing Technology Program (MT) and administered by the Manufacturing and Computer Integrated Engineering (CIE) Technology Branch, Code 936, of the Naval Command, Control and Ocean Surveillance Center, RDT&E Division (NRaD), San Diego, California 92152-5000. Technical assistance and program monitoring for the study were provided by R. L. McCollough and C. C. Azu, Jr., of NRaD Code 936. This document was developed during the Microelectronic Computer Integrated Manufacturing (MCIM) Program, and it supports "Hybrid Microcircuit Application Protocol," written by the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland.

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Hybrid Microcircuit Assembly Manufacturing Process Parameters Data List

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Hybrid Microcircuit Assembly
Manufacturing Process Parameters
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1.0 Introduction

The Hybrid Microcircuit Assembly manufacturing process parameters have been established in order to bring about their recognition and control. The list is of generic thin film, thick film and multi-chip modules constructed with multi-layer green tape alumina and substrates. The list starts with substrate fabrication and progressing through to final assembly, inspection, and test. Once the parameters have been fully recognized and completely described, progress can be made in regulating the parameters. This regulation will bring about cost effective requirements and a higher quality product. Another benefit will come from knowing the parameters that need further scrutiny. The possible combining of manufacturing functions or techniques can in the future change the parameters but the new parameters can be compared with the old.

There are eleven separate categories in the list and they are defined as follows:

OPERATION NUMBER - provides a four digit number to identify process steps. Will be used for process flow analysis and throughput calculations.

PROCESS DESCRIPTION - identifying name of process step.

PROPERTY - primary manufacturing properties of the process.

UNITS OF MEASURE -the units of measure of the process parameters.

TYPICAL VALUE/RANGE - the typical value or range of values of the generic process parameters.

SPC FORMAT - the method of measuring and tracking the process conditions for statistical process control.

DATA (ACQUISITION) - the typical method or equipment for fabrication, assembly, inspection and test in today's hybrid microelectronic manufacturing facility.

PROCESS TYPE - the typical method or equipment for fabrication, assembly, inspection and test in today's hybrid microelectronic manufacturing facility.

CONTROLLING DOCUMENT - the contractually imposed specification, applicable to the process operation or to the specific property in that operation.

CAD (LAYER) - nomenclature specified in the "IGES HMA Application Protocol" for the process or the specified property.

IDEF (NODE) - the IDEF node(s) being specified in the "IGES HMA Application Protocol".

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2.0 Thin film manufacturing process parameters

After having selected the substrate material, the next step in the fabrication of thin film microcircuits is the deposition of metals or metal compounds onto the substrate. These metals ultimately provide the conductor and resistor patterns and functions. Typically, a substrate is coated sequentially with a layer of resistive material, a barrier metal layer, and a top conductor layer. These layers are relatively thin ranging from 200A to 20,000A. The layers are deposited by one of the following methods, Vapor Deposition, Direct Current Sputtering, Radio-Frequency Sputtering, and Reactive Sputtering or variations of the processes. The following is a list of processing parameters used for thin film substrates for Hybrid Microcircuits. An attempt has been made to keep the list generic so as it does not represent anyone manufacturers processing ways.

GENERIC, THIN FILM FABRICATION PROCESS FLOW

OPERATION #	PPOCESS DESCRIPTION	PROPERTY	UNITS OF MEASURE	TYPCAL VALUE/RANGE	SPC FORMAT	DATA	PROCESS TYPE	CONTROLLING DOCUMENT
2010	IDENTIFY SUBSTRATE	Alpha-numeric & bar code images	$String$	?				
2010		Marking locations	?	?				
2010		Legibility	?	?				
2020	CLEAN SUBSTRATE	?	?	?				
2030	SCREEN CIRCUIT LAYER	Screen mesh	Wires/Inch	?			Automatic	
2030		Screen tension	?	?			Automatic	
2030		Screen breakaway distance	Mils	?			Automatic	
2030		Squeegee applied pressure	Lbs/sq.in / linear in.	1-10 psi/in. of squeegee			Automatic	
2030		Squeege deposition velocity	Inches/second	2-6			Automatic	
2030		Squeegee hardness	Durometers	?			Automatic	
2030		Substrate to screen distance	Mils	?			Automatic	
2030		Number of squeegee passes	Unitless	1, 2, or 3			Automatic	
2030		Material properties	?	?	X bar-R	Manual	Automatic	
2030		Material properties	?	?	X bar-R	Manual	Automatic	
2030		Minimum layer thickness	Mils	?			Automatic	
2030		Maximum layer thickness	Mils	?			Automatic	
2030		Emulsion thickness on screen	Mils	2-3			Automatic	
2030		Screen weave angle to substrate	Angular degrees	22, 45, or 90			Automatic	
2030		Substrate registration to screen	X-mils, Y-mils	?			Automatic	
2030		Screening defects	?	?	NP			
2040	DRY CIRCUITRY	Environment	$Strings$	Oven, IR lamps, etc.			Batch	
2040	(to remove volatiles)	Drying temperature	Degrees C	180			Batch	
2040		Drying time	minutes	5-15			Batch	

2040		Drying wavelength (IR)	Microns	>3			Batch	
2050	FIRE CIRCUITRY	Environment	$String$	Oven, furnace, etc.				
2050		Temperature profile	Time vs Degrees C	5 min @ 300 C, etc.				
2060	INSPECT CIRCUITRY	Conductor conductivity	Volts	?	X bar-R	Manual		
2060		Wire pull strength	Grams	?	X bar-R	Manual		
2060		Solderability	?	?	X bar-R	Manual		
2070	SCREEN PASSIVATION LAYER	Screen mesh	Wires/inch	?			Automatic	
2070		Screen tension	?	?			Automatic	
2070		Screen breakaway distance	Mils	?			Automatic	
2070		Squeegee applied pressure	Lbs/sq.in per linear inch	1-10 psi/in. of squeegee			Automatic	
2070		Squeege deposition velocity	Inches/second	2-6			Automatic	
2070		Squeege hardness	Durometers	?			Automatic	
2070		Substrate to screen distance	Mils	?			Automatic	
2070		Number of squeege passes	Unitless	1, 2, or 3			Automatic	
2070		Material properties	?	?			Automatic	
2070		Minum layer thickness	Mils	?			Automatic	
2070		Maximum layer thickness	Mils	?			Automatic	
2070		Emulsion thickness on screen	Mils	2-3			Automatic	
2070		Substrate registration to screen	X-mils, Y-mils	?			Automatic	
2070		Screen weave angle to substrate	Angular degrees	22, 45, or 90			Automatic	
2070		Material viscosity	Centipoise	?	X bar-R	Manual		
2080	DRY PASSIVATION LAYER	Environment	$String$	Oven, IR lamps, etc.				
2080		Drying temperture	Degrees Centigrade	180				
2080		Drying time	Minutes	5-15				
2080		Drying wavelength (IR)	Microns	>3				
2090	FIRE PASSIVATION LAYER	Environent	$Srings$	Oven, furnace, etc.				

2090		Temperature profile	Time vs degrees C	5 min. @ 300 C, etc				
2100	INSPECT PASSIVATION	Crossover capacitance	Farads	?	X bar-R	Manual		
2100		Dielectric breakdown	Volts	?	X bar-R	Manual		
2110	APPLY EPOXY	?	?	?				MIL-STD-883,METHOD 2019.4
2120	ATTACH RESISTOR CHIPS	?	?	?				MIL-STD-883,METHOD 5011.
								MIL-STD-883,METHOD 2017.7
								MIL-STD-883,METHOD 2011.5
2130	OVEN CURE	?	?	?				MIL-STD-883,METHOD 2017.5
2140	WIRE BOND RESISTORS	Bond height	Z-mils	10				MIL-STD-883,METHOD 2023.3
2140		Bonding force - first & second bond	Grams	10				MIL-STD-883,METHOD 5003
2140		Bonding power	Microinches	0-250				
2140		Bonding time	Milliseconds	100				
2140		Location of first bond	X-mils, Y-mils	?				
2140		Location of second bond	X-mils, Y-mils, Z-mils	?				
2140		Loop height, loop length	Mils/mils	6-20/10-200				
2140		Tail length	Mils	2				
2140		Wire diameter	Mils	1				
2140		Wire material	$String$	Gold or Aluminum				
2140		Wire doping material/percentage	$String$	Silicon/1.0%				
2140		Wire material purity	Percent purity	99.999				
2140		Wire elongation	Percent	3-7				
2140		Wire tensile strength	Grams	15				
2140		Time from last cleaning operation	Hours, date (yymmdd)	16, 910322				
2140		Bond signature	?	?				
2150	TRIM RESISTORS, ACTIVE	Name of component to be trimmed	$String$	R17			Automatic	
2150	(Using Laser Process)	Location of start of trim	X-mils, Y-mils	xx.xxx, yy.yyy			Automatic	
2150		Coordinate data for path of trim	X-mils, Y-mils	xx.xxx, yy.yyy			Automatic	

2150		Pulse repetition rate	Kilohertz	35			Automatic	
2150		Resistor trim geometry	$String$	"L", :J", or Plunge Cut			Automatic	
2150		Type of laser used in trimming	$String$	YAG, Co2, etc.			Automatic	
2150		Laser power, maximum	Watts	15			Automatic	
2150		Laser power, minimum	Watts	12			Automatic	
2150		Spot size	Microns	0.002			Automatic	
2150		Target resistance	Ohms	1000			Automatic	
2150		Target resistance tolerance	Ohms	0.1			Automatic	
2150		Trim speed, course	Mils/second	n/a			Automatic	
2150		Trim speed, fine	Mils/second	n/a			Automatic	
2150		Trim kerf width	Mils	0.002 (spot size)			Automatic	
2150		Trim width, minimum	Mils	+/- 0.010			Automatic	
2150		Parameter to be measured	$String$	3.5 vdc at TP1			Automatic	
2150		Tolerance of parameter measured	$String$	+ 0.02 vdc			Automatic	
2150		Operating conditions for trim	$String$	Vcc=5.0, at -55 C			Automatic	
2160	INSPECT	?	?					
2170	TO NEXT ASSEMBLY OR STORES	n/a	n/a	n/a				
	FOR MULTI-LAYER SUBSTRATES :							
2200	IDENTIFY SUBSTRATE	?	?	?				
2210	CLEAN SUBSTRATE	?	?	?				
2220	SCREEN CIRCUIT LAYER	Screen mesh	Wires/inch	?			Automatic	
2220		Screen tension	?	?			Automatic	
2220		Screen breakaway distance	Mils	?			Automatic	
2220		Squeegee applied pressure	Lbs/sq.in per linear inch	1-10 psi/in. of squeegee			Automatic	
2220		Squeegee hardness	Durometers	?			Automatic	
2220		Substrate to screen distance	Mils	?			Automatic	
2220		Number of squeegee passes	Unitless	1, 2, or 3			Automatic	

2220		Material properties	?	?	X bar-R	Manual	Automatic	
2220		Material properties	?	?	X bar-R	Manual	Automatic	
2220		Minimum layer thichness	Mils	?			Automatic	
2220		Maximum layer thickness	Mils	?			Automatic	
2220		Emulsion thickness on screen	Mils	2-3			Automatic	
2220		Screen weave angle to substrate	Angular degrees	22, 45, or 90			Automatic	
2220		Substrate registration to screen	X-mils, Y-mils	?			Automatic	
2220		Screening defects	?	?	NP		Automatic	
2230	DRY CIRCUITRY	Environment	$String$	Oven, IR lamps, etc.				
2230		Drying temperature	Degrees Centigrade	180				
2230		Drying time	Minutes	5-15				
2230		Drying wavelength (IR)	Microns	>3				
2240	FIRE CIRCUITRY	Environment	$String$	Oven, furnace, etc.				
2240		Temperature profile	Time vs degrees C	5 min. @ 300 C, etc.				
2250	INSPECT CIRCUITRY	Conductor conductivity	Volts	?	X bar-R	Manual		
2250		Wire pull strength	Grams	?	X bar-R	Manual		
2250	(Repeat Above 4 Operations For	Additional Layers As Required)						
2260	SCREEN DIELECTRIC LAYER	Screen mesh	Wires/inch	?			Automatic	
2260		Screen tension	?	?			Automatic	
2260		Screen breakaway distance	Mils	?			Automatic	
2260		Squeegee applied pressure	Lbs/sq.in per linear inch	1-10 psi/in. of squeegee			Automatic	
2260		Squeegee deposition velocity	Inches/second	2-6			Automatic	
2260		Squeegee hardness	Durometers	?			Automatic	
2260		Substrate to screen distance	Mils	?			Automatic	
2260		Number of squeegee passes	Unitless	1, 2, or 3			Automatic	
2260		Material properties	?	?	X bar-R	Manual	Automatic	

2260		Material viscosity	Centipoise	?	X bar-R	Manual	Automatic	
2260		Minimum layer thichness	Mils	?			Automatic	
2260		Maximum layer thicknes	Mils	?			Automatic	
2260		Emulsion thickness on screen	Mils	2-3			Automatic	
2260		Screen weave angle to substrate	Angular degrees	22, 45, or 90			Automatic	
2260		Substrate registration to screen	X-mils, Y-mils	?			Automatic	
2270	DRY DIELECTRIC LAYER	Environment	$Strings$	Oven, IR lamps, etc.			Batch	
2270		Drying temperature	Degrees Centigrade	180			Batch	
2270		Drying time	Minutes	5-15			Batch	
2270		Drying wavelength (IR)	Microns	>3			Batch	
2280	FIRE DIELECTRIC LAYER	Environment	$String$	Oven, furnace,etc.				
2280		Temporature profile	Time vs degrees C	5 min. @ 300 C, etc.				
2290	INSPECT DIELECTRIC LAYER	Crossover capacitance	Farads	?	X bar-R	Manual		
2290		Dielectric breakdown	Volts	?	X bar-R	Manual		
2290	(Repeat Above 4 Operations For	Each Additional Circuit Layer)						
2300	APPLY EPOXY	?	?	?				
2310	ATTACH RESISTOR CHIPS	?	?	?				MIL-STD-883,METHOD 2019.4
2310								MIL-STD-883,METHOD 5011
2310								MIL-STD-883,METHOD 2017.7
2320	OVEN CURE	?	?	?				
2330	WIRE BOND RESISTORS	Bond height	Z-mils	10			Automatic	MIL-STD-883,METHOD 2011.5
2330		Bonding force- first & second bond	Grams	10			Automatic	MIL-STD-883,METHOD 2017.5
2330		Bonding power	Microinchess	0-250			Automatic	MIL-STD-883,METHOD 2023.3
2330		Bonding time	Miliseconds	100			Automatic	MIL-STD-883,METHOD 5003
2330		Location of first bond	X-mils, Y-mils	?			Automatic	
2330		Location of second bond	X-mils, Y-mils, Z-mils	?			Automatic	

2330		Loop height, loop length	Mils/mils	6-20/10-200			Automatic	
2330		Tail length	Mils	2			Automatic	
2330		Wire diameter	Mils	1			Automatic	
2330		Wire material	$String$	Gold or Aluminum			Automatic	
2330		Wire doping material/percentage	$String$	Silicon/1.0%			Automatic	
2330		Wire material purity	Percent purity	99.999			Automatic	
2330		Wire elongation	Percent	3-7			Automatic	
2330		Wire tensile strength	Grams	15			Automatic	
2330		Time from last cleaning operation	Hours, date (yymmdd)	16, 910322			Automatic	
2330		Bond signature	?	?			Automatic	
2340	TRIM RESISTORS, ACITVE	Name of component to be trimmed	$String$	R17			Automatic	
2340	(Using Laser Process)	Location of start of trim	X-mils, Y-mils	xx.xxx, yy.yyy			Automatic	
2340		Coordinate data for path of trim	X-mils, Y-mils	xx.xxx, yy.yyy			Automatic	
2340		Pulse repetition rate	Kilohertz	35			Automatic	
2340		Resistor trim geometry	$String$	"L", :J", or Plunge Cut			Automatic	
2340		Type of laser use in trimming	$String$	YAG, Co2, etc.			Automatic	
2340		Laser power, maximum	Watts	15			Automatic	
2340		Laser power, minimum	Watts	12			Automatic	
2340		Spot size	Microns	0.002			Automatic	
2340		Target reistance	Ohms	1000			Automatic	
2340		Target resistance tolerance	Ohms	+/- 0.1			Automatic	
2340		Trim speed, course	Mils/second	n/a			Automatic	
2340		Trim speed, fine	Mil/second	n/a			Automatic	
2340		Trim kerf width	Mils	0.002 mils (spot size)			Automatic	
2340		Trim width, minimum	Mils	0.010			Automatic	
2340		Parameter to be measured	$String$	3.5 vdc at TP1			Automatic	
2340		Tolerance of parameter measured	$String$	+/- 0.02 vdc			Automatic	

2340		Operating conditions for trim	$String$	Vcc=5.0,@ minus 55 C			Automatic	
2350	INSPECT	?	?	?			Automatic	
2360	TO NEXT ASSEMBLY OR STORES	n/a	n/a	n/a			n/a	n/a
	GENERIC THIN FILM ASSEMBLY PROCESS FLOW							
2400	PLASMA CLEAN	Operating frequency	MHz	13				
2400		Operating presure	Microns (Hg)	5				
2400		Power, RF	Watts	100				
2400		Cleaning time	Minutes	10				
2400		Gases for plasma	$String$	Oxygen, Argon, etc.				
2400		Partial pressure of atmosphere	Percent	10% Oxygen, 90% Argon				
2400		Number of units to be cleaned (load)	Unitless	?				
2410	SCREEN CONDUCTIVE EPOXY	Screen mesh	Wire/inch	?				MIL-STD-883,METHOD 2017.7
2410		Screen tension	?	?				MIL-STD-883,METHOD 2019.4
2410		Screen breakaway distance	Mils	?				MIL-STD-883,METHOD 5011
2410		Squeegee applied pressure	Lbs/sq.in per linear inch	1-10 psi/in. of squeegee				
2410		Squeegee deposition velocity	Inches/second	2-6				
2410		Squeegee hardness	Durometers	?				
2410		Substrate to screen distance	Mils	?				
2410		Number of squeegee passes	Unitless	1, 2, or 3				
2410		Material properites	?	?				
2410		Material properties						
2410		Minimum layer thickness	Mils	?				
2410		Maximum layer thickness	Mils	?				
2410		Emulsion thickness on screen	Mils	2-3				
2410		Screen weave angle to substrate	Angular degrees	22, 45, or 90				
2410		Substrate registration to screen	X-mils, Y-mils	?				

2420	CURE EPOXY	?						
2430	ATTACH ACTIVE COMPONETS	?	?	?				MIL-STD-883,METHOD 2017.7
2430								MIL-STD-883,METHOD 2019.4
2430								MIL-STD-883,METHOD 5011
2440	OVEN CURE	?	?	?				MIL-STD-883,METHOD 2017.7
2440								MIL-STD-883,METHOD 2019.4
2440								MIL-STD-883, METHOD 5011
2450	APPLY NONCONDUCTIVE EPOXY	?	?	?				MIL-STD,883 METHOD 2017.7
2450	(Spot dispensing method)							MIL-STD-883,METHOD 2019.4
2450								MIL-STD-883, METHOD 5011
2460	CURE EPOXY	?	?	?				
2470	ATTACH PASSIVE COMPONETS	?	?	?				MIL-STD-883,METHOD 2017.7
2470								MIL-STD-883,METHOD 2019.4
2470								MIL-STD-883,METHOD 5011
2480	OVEN CURE	?	?	?				
2490	WIRE BOND, THERMOSONIC	Bond height	Z-mils	10				MIL-STD-883,METHOD 2011.5
2490		Bonding force-first & second bond	Grams	20-500				MIL-STD-883-METHOD 2017.5
2490		Bonding temperature - capillary	Degrees Centigrade	20				MIL-STD-883,METHOD 2017.5
2490		Bonding temperature- substrate	Degrees Centigrade	150-200				MIL-STD-883,METHOD 2023.3
2490		Bonding time-first & second bond	Milliseconds	1-999				
2490		Bonding power- first & second bond	Watts	First 1.3,Second 1.3 watt				
2490		Ball size	Mills	0.7				
2490		Location of first bond (ball)	X-mils, Y-mils, Z-mils	?				
2490		Location of second bond (stitch)	X-mils, Y-mils, Z-mils	?				

2490		Loop height, loop length	Mils/Mils	6-20/10-200				
2490		Wire diameter	Mils	1-2				
2490		Wire tensile strength	Grams	15				
2490		Wire material	$String$	Gold				
2490		Wire material purity	Percent purity	99.999				
2490		Wire doping material/percent	$String$	Silicone/1.0%				
2490		Wire elongation	Percent	3-7				
2490		Wire tension in bonding machine	Grams	10				
2490		Time from last cleaning operation	Hours, date (yymmdd)	16, 910322				
2500	WIRE BOND, ULTRASONIC	Bond height	Z-mils	10				MIL-STD-883,METHOD 2011.5
2500	(Die to substrate)	Bonding force -first & second bond	Grams	10				MIL-STD-883,METHOD 2017.5
2500		Bonding power	Microinches	0-250				MIL-STD-883,METHOD 2023.3
2500		Bonding time	Milliseconds	100				MIL-STD-883,METHOD 5003
2500		Location of first bond	X-mils, Y-mils	?				
2500		Location of second bond	X-mils, Y-mils, Z-mils	?				
2500		Loop height, loop length	Mils/mils	6-20/10-200				
2500		Tail length	Mils	2				
2500		Wire diameter	Mils	1				
2500		Wire material	$String$	Gold or aluminum				
2500		Wire doping material/percentage	$String$	Silicon/1.0%				
2500		Wire material purity	Percent purity	99.999				
2500		Wire elongation	Percent	3-7				
2500		Wire tensile strength	Grams	15				
2500		Time from last cleaning operation	Hours, date (yymmdd)	16, 910322				
2500		Bond signature	?	?				
2510	WIRE BOND PULL TEST	Location of first bond	X-mils, Y-mils, Z-mils	?				MIL-STD-883,METHOD 2011.5

2510		Location of second bond	X-mils, Y-mils, Z-mils	?				MIL-STD-883,METHOD 2023.3
2510		Location of hook	X-mils, Y-mils, Z-mils	?				MIL-STD-883,METHOD 5003
2510		Hook size relative to wire size	Ratio	2:1				
2510		Applied force	Grams	3-20 (1 mil wire)				
2510		Angle of pull from normal	Degrees	0				
2510		Precondition temperature	Degrees Centigrade	300 C				
2510		Precondition time	Hours	1				
2510		Wire diameter	Mils	1				
2510		Wire material	$String$	Gold, Aluminum				
2510		Sample size	Unitless	20 out of 100				
2510		Failure criteria, min.,ave.,sigma	Grams	1.2, 2, and 3				
2520	CLEAN HEADER	Solvent name	$String$	Alcohol				
2520		Solvent identification data	$String$	Mfgrs. name, partnumber				
2520		Solvent cleaning time	Minutes	1.0 min				
2520		Solvent cleaning temperature	Degrees Centigrade	105 +/- 5				
2520		Drying time	Minutes	1.0				
2520		Drying temperature	Degrees centigrade	105 +/-5				
2530	MARK HEADER	?	?	?				
2540	CURE MARKING	?	?	?				
2550	MOUNT SUBSTRATE TO HEADER	?	?	?				
2560	OVEN CURE	?	?	?				
2570	WIRE BOND	Bond height	Z-mils	10				
2570	(Substrate to header)	Bonding force-first and second bond	Grams	20-500				
2570		Bonding temperature - capillary	Degrees Centigrade	20				

2570		Bonding temperature - substrate	Degrees Centigrade	150-200				
2570		Bonding time - first and second bond	Milliseconds	1-999				
2570		Bonding power- first and second bond	Watts	First 1.3,Second 1.3 watt				
2570		Ball size	Mills	0.7				
2570		Location of first bond (ball)	X-mils, Y-mils	?				
2570		Location of second bond (stitch)	X-mils, Y-mils, Z-mils	?				
2570		Loop height, loop length	Mils/mils	6-20/10-200				
2570		Wire diameter	Mils	1-2				
2570		Wire tensile strength	Grams	15				
2570		Wire material	$String$	Gold				
2570		Wire material purity	Percent purity	99.999				
2570		Wire doping material/percentage	$String$	Silicone/1.0%				
2570		Wire elongation	Percent	3-7				
2570		Wire tension in bonding machine	Grams	10				
2570		Time from last cleaning operation	Hours, date (yymmdd)	16 910322				
2580	WIRE BOND PULL TEST	Location of first bond	X-mils, Y-mils, Z-mils	?				
2580		Location of second bond	X-mils, Y-mils, Z-mils	?				
2580		Location of hook	X-mils, Y-mils, Z-mils	?				
2580		Hook size relative to wire size	Ratio	2:1				
2580		Applied force	Grams	?				
2580		Angle of pull from normal	Degrees	0				
2580		Precondition temperature	Degree Centigrade	300				
2580		Precondition time	Hours	1				
2580		Wire diameter	Mils	1				
2580		Wire material	$String$	Gold, Aluminum				

2580		Sample size	Unitless	20 out of 100				
2580		Failure criteria, min., ave., sigma	Grams	1.2, 2, and 3				
2590	FUNCTIONAL ELECTRICAL TEST	Test interface adapter	$String$	Part number identifier				MIL-STD-883,METHODS 3001-3015
2590		Test procedure	$String$	Part number identifier				MIL-STD-883,METHODS 4001-4007
2590		Date of test	Date (yymmdd)	911204				MIL-STD-883, METHODS 5001-5010
2590		Electrical parameters	?	?				
2590								MIL-STD-883, METHODS 5001-5010
2600	PRE-CAP VISUAL INSPECTION	?	?	?				
2610	CLEAN COVER	Solvent name	$String$	Alcohol				
2610		Solvent identification data	$String$	Mfgrs. name, part number				
2610		Solvent cleaning time	Minutes	1.0 min				
2610		Solvent cleaning temperature	Degrees Centigrade	105 +/- 5				
2610		Drying time	Minutes	1.0 min				
2610		Drying temperature	Degrees Centigrade	105 +/- 5				
2620	TACK COVER IN PLACE	?	?	?				
2630	BAKE - 24 HR. NITROGEN	?	?	?				
2640	BAKE - 24 HR. VACUUM	?	?	?				
2650	SEAL COVER	Ambient environment	Percent gas composition	90 % N 10% He				
2650	(Parallel seam weld process)	Environmental moisture level	Part/million water vapor	100				
2650		Pulse repetition time	Milliseconds	80-100				
2650		Pulse width (duration)	Milliseconds	60				
2650		Table speed	Inches/minute	1-2				
2650		Weld current	Amperes	360 +/- 20				
2650		Weld force	Grams	800				

2650		Material thickness at weld edge	Mils	0.012				
2650		Material to be welded	$String$	Kovar				
2660	FINE LEAK TEST	?	?	?				
2670	GROSS LEAK TEST	?	?	?				
2680	MARK PACKAGE	Alpha-numeric & bar code images	?	?				
2680		Marking locations						
2680		Legibility						
2690	CURE MARKING	Solvent resistance	?	?				
2700	FUNCTIONAL ELECTRICAL TEST	Test interface adapter	$String$	Part number identifier				MIL-STD-883, METHODS 3001-3015
2700		Test procedure	$String$	Part number identifier				MIL-STD-883, METHODS 4001-4007
2700		Date of test	Date (yymmdd)	911204				MIL-STD-883, METHODS 5001-5010
2700		Electrical parameters	?	?				
2710	BURN-IN	Test chamber temperature	?	?				MIL-STD-883, METHOD 1015.6
2710		Duration at temperature	?	?				MIL-STD-883, METHOD 5004.7
2720	FUNCTIONAL ELECTRICAL TEST	Test interface adapter	$String$	Part number identifer				MIL-STD-883, 3001-3015
2720		Test procedure	$String$	Part number identifier				MIL-STD-883, METHODS 4001-4007
2720		Date of test	Date (yymmdd)	911204				MIL-STD-883, METHODS 5001-5010
2720		Electrical parameters	?	?				
2730	STABILIZATION BAKE	Environment	$String$	Nitrogen				MIL-STD-883, METHOD 1008.2
2730		Temperature	Degrees Centigrade	105				MIL-STD-5008.4
2730		Time	Hours	24				
2740	TEMPERATURE CYCLE	Environment	$String$	Nitrogen				MIL-STD-883, METHOD 1010.5
2740		Cycles	Unitless	10				MIL-STD-883, METHOD 1011.9
2740		Temperature	Degrees C/step	-65 +125				
2740		Time at each temperature cycle	Minutes	10,10				

2740		Transfer time	Seconds	6				
2750	PHYSICAL STRESS TEST	Force axis	Direction	Y <sub> 1				MIL-STD-883,METHOD 2001.2
2750	(Using centrifuge method)	Force magnitude	G's	5000				
2750		Time subjected to force	Minutes	1				
2760	FINE LEAK BOMB	Ambient pressure vesel pressure	Pounds/square inch	30-60				
2760	(He tracer gas method)	Time under pressure	Minutes	120				
2760		Internal volume of package	Cubic Centimeters	1				
2770	FINE LEAK TEST	Dwell time, pressure rel. to test	Minutes	160				
2780	GROSS LEAK BOMB	Fluorocarbon type	$String$					
2780		Fluorocarbon temperature	Degrees Centigrade	125 +/- 5				
2780		Immersion time	Seconds	30				
2790	GROSS LEAK TEST	?	?					
2800	PIND TEST	?	?	?				MIL-STD-883, METHOD 2020.6
2810	INSPECT	?	?	?				
2820	PACKAGE & LABEL FOR SHIPPING	Prepare tracibility documents	n/a	n/a		n/a	n/a	n/a

Hybrid Microcircuit Assembly
Manufacturing Process Parameters
Data List

3.0 Thick film manufacturing process parameters

Thick film circuits are produced by the screen-printing process. Silk mesh screening is good for sign making but is not used in electronics manufacturing because of its dimentional instability and poor abrasion resistance. The mesh of choice is stainless steel, though sometimes synthetic fibers such as Dacron (polyester) or Nylon (polyamide) are used. The three key processes used to fabricate thick-film circuits are; screen-printing, drying and firing. The following is a list of processing parameters used for thick film substrates for Hybrid Microcircuits. An attempt has been made to keep the list generic so as it does not represent anyone manufacturers processing ways.

GENERIC, THICK FILM FABRICATION PROCESS FLOW

OPERATION #	PROCESS DESCRIPTION	PROPERTY	UNITS OF MEASURE	TYPICAL VALUE/RANGE	SPC FORMAT	DATA	PROCESS TYPE	CONTROLLING DOCUMENT
0010	IDENTIFY SUBSTRATE	Alph-numeric & bar code images	N/A	N/A				
0010		Marking locations	N/A	N/A				
0010		Legibility	N/A	N/A				
0020	CLEAN SUBSTRATE	Chemical Properties	N/A	N/A				
0030	SCREEN CIRCUIT LAYER	Screen mesh	Wires/Inch	200-325			Automatic	
0030		Screen tension	?	?			Automatic	
0030		Screen breakaway distance	Millimeters	?			Automatic	
0030		Squeegee applied pressure	Lbs/sq.in per linear inch	1-10 psi/in. of squeegee			Automatic	
0030		Squeegee deposition velocity	Inches/second	2-6			Automatic	
0030		Squeegee hardness	Durometers	60-75			Automatic	
0030		Substrate to screen distance	Millimeters	30			Automatic	
0030		Number of squeegee passes	Unitless	1, 2, or 3			Automatic	
0030		Particle size material properties	Microns	10	X bar-R	Manual	Automatic	
0030		Viscosity material properties	Centipoise	200,000	X bar-R	Manual	Automatic	
0030		Minimum layer thickness	Millimeters	.5			Automatic	
0030		Maximum layer thickness	Millimeters	2			Automatic	
0030		Emulsion thickness on screen	Millimeters	.3 - .8			Automatic	
0030		Screen weave angle to substrate	Angular degrees	45			Automatic	
0030		Substrate registration to screen	X-millimtrs, Y-millimtrs	+/- 2			Automatic	
0030		Screening defects	N/A	N/A	NP		Automatic	
0040	DRY CIRCUITRY	Environment	$Strings$	Oven, IR lamps, etc.			Batch	
0040	(to remove volatiles)	Drying temperature	Degrees Centigrade	180			Batch	
0040		Drying time	Minutes	5-10			Batch	

0040		Drying wavelength (IR)	Microns	>3				
0040		Min/max layer thick	Millimeter	.5/2				
0050	FIRE CIRCUITRY	Environment	$String$	Oven, furnace, etc.				
0050		Temperature profile	Time vs Degrees Centigrde	5 min @ 300 C, etc.				
0050		Min/Max layer thick	Millimeter	.3/1.4				
0060	INSPECT CIRCUITRY	Conductor resistivity	miliohms/sq. in.	3-100	X bar-R	Manual		
0060		Wire pull strength (1 mil gold)	Grams	5	X bar-R	Manual		
0060		Solderability Adhesion	lbs./sq. in.	400	X bar-R	Manual		
0070	SCREEN RESISTORS	Screen mesh	Wires/inch	200-325			Automatic	
0070		Screen tension	?	?			Automatic	
0070		Screen breakaway distance	Millimeters	?			Automatic	
0070		Squeegee applied pressure	Lbs/sq.in per linear inch	1-10 psi/in. of squeegee			Automatic	
0070		Squeegee deposition velocity	Inches/second	2-6			Automatic	
0070		Squeegee hardness	Durometers	60 - 75			Automatic	
0070		Substrate to screen distance	Millimeters	30			Automatic	
0070		Number of squeegee passes	Unitless	1, 2, or 3			Automatic	
0070		Ink percent solids	Percent	70			Automatic	
0070		Ink viscosity	Centipoise	170,000 - 340,000	X bar-R	Manual	Automatic	
0070		Emulsion thickness on screen	Millimeter	.8			Automatic	
0070		Screen weave angle to substrate	Angular degrees	45			Automatic	
0070		Substrate registration to screen	X-millimtrs, Y-millimtrs	+/- 2			Automatic	
0070		Area of screened resistor	Square millimeter	1600			Automatic	
0070		Effective ink resistivity	Ohm/square	.25 - 1 M	X bar-R	Manual	Automatic	
0070		Resistance stability (time @ temp)	% change in value	< 0.2			Automatic	
0070		Film thickness	Angstroms (or Microns?)	300 A, 400A (or?)	X bar-R	Manual	Automatic	
0070		Minimum line width	Millimeter	30			Automatic	

0070		Aspect ratio	Unitless	4:1			Automat.c	
0070		Geometry type	$String$	Rectangle, top hat, etc.			Automatic	
0070		Resistor to pad overlap	Millimeter	5			Automatic	
0070		Pad offshoot off resistor side	Millimeter	6			Automatic	
0070		Pad offshoot off resistor end	Millimeter	10			Automatic	
0070		Growth factor per edge	Millimeter	.5			Automatic	
0070		Etch back factor per edge	Millimeter	.6			Automatic	
0070		Corner value	Unitless	.5			Automatic	
0070		Resistor geometry resolution	Millimeter	5			Automatic	
0070		Room temperature for screening	Degrees Centigrade	22			Automatic	
0070		Room humidty for screening	Percent	< 60			Automatic	
0070		Ink storage conditions	$String$	Room temp on ball mill			Automatic	
0070		Ink procurement data	$String$	Mfgrs. name, part no.,etc			Automatic	
0070		Ink shelf life data-date of receip	Date-yymmdd	910402			Automatic	
0070		Ink shelf life	Days	90			Automatic	
0080	DRY RESISTORS	Environment	$String$	Oven, IR lamps, etc.			Batch	
0080	(to remove voltiles)	Drying temperture	Degrees Centigrade	180			Batch	
0080		Drying time	Minute	5-15			Batch	
0080		Drying wavelength (IR)	Micron	>3			Batch	
0090	FIRE RESISTORS	Environment	$Srings$	Oven, furnace, etc.				
0090		Temperature profile	Time vs. Degrees C	5 min. @ 300 C, etc				
0100	INSPECT RESISTORS	Thickness	Millimeter	.4 - 1	X bar-R	Manual		
0100		Resistance	Ohms	.1 - 5M	X bar-R	Manual		
0110	SCREEN PASSIVATION LAYER	Screen Mesh	Wires/inch	325			Automatic	
0110		Screen tension	?	?			Automatic	

0110		Screen breakaway distance	Millimeter	?			Automatic	
0110		Squeegee applied pressure	Lbs/sq.in per linear inch	1-10 psi/in. of squeegee			Automatic	
0110		Squeegee deposition velocity	Inches/second	2-6			Automatic	
0110		Squeegee hardness	Durometers	60-75			Automatic	
0110		Substrate to screen distance	Millimeter	30			Automatic	
0110		Number of squeegee passes	Unitless	1, 2, or 3			Automatic	
0110		Solids content material properties	%	70			Automatic	
0110		Minimum layer thickness	Millimeter	1			Automatic	
0110		Maximum Layer thickness	Millimeter	2			Automatic	
0110		Emulsion thickness on screen	Millimeter	.8			Automatic	
0110		Screen weave angle to substrate	Angular degrees	45			Automatic	
0110		Substrate registration to screen	X-millimtr, Y-millimtr	+/-2			Automatic	
0110		Material viscosity	Centopoise	70,000-300,000	X bar-R	Manual	Automatic	
0120	DRY PASSIVATION LAYER	Environment	$String$	Oven, IR lamps, etc.				
0120		Drying temperature	Degrees Centigrade	180				
0120		Drying time	Minute	5-15				
0120		Drying wavelength (IR)	Micron	>3				
0130	FIRE PASSIVATION LAYER	Environment	$String$	Oven, furnace, etc.				
0130		Temperature profile	Time vs Degrees Centigrad	5 min. @ 300 C, etc				
0140	INSPECT PASSIVATION	Crossover capacitance	PF/IN2/2MIL	4000 MAX	X bar-R	Manual		
0140		Dielectric breakdown	Volts/MIL	100	X bar-R	Manual		
0150	TRIM RESISTORS, PASSIVE	Name of component to be trimmed	$String$	R17			Automatic	
0150	(Using Laser Process)	Location of start of trim	X-millimtr, Y-millimtr	xx.xxx, yy.yyy			Automatic	
0150		Coordinate data for path of trim	X-millimtr, Y-millimtr	xx.xxx, yy.yyy			Automatic	
0150		Pulse repetition rate	Kilohertz	35 kHz			Automatic	
0150		Resistor trim geometry	$String$	"L", "J" or Plunge Cut			Automatic	

0150		Type of laser used in trimming	$String$	YAG, Co2, etc.			Automatic	
0150		Laser power, maximum	Watt	15			Automatic	
0150		Laser power, minimum	Watt	12			Automatic	
0150		Spot size	Micron	0.002			Automatic	
0150		Resistor resistance	Ohm	1000			Automatic	
0150		Resistor resistance tolerance	Ohm	+0.1			Automatic	
0150		Trim speed, course	Millimeter/second	n/a			Automatic	
0150		Trim speed, fine	Millimeter/second	n/a			Automatic	
0150		Trim kerf width	Millimeter	0.002 (spot size)			Automatic	
0150		Trim width, minimum	Millimeter	0.010			Automatic	
0160	INSPECT	?	?	?			Automatic	
0170	TO NEXT ASSEMBLY OR STORES	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	For Multi-layer Substrates :							
0200	IDENTIFY SUBSTRATE	?	?	?				
0210	CLEAN SUBSTRATE	Chemical properties	N/A	N/A				
0220	SCREEN CIRCUIT LAYER	Screen mesh	Wires/inch	325			Automatic	
0220		Screen tension	M deflection/lbs of force	57-73			Automatic	
0220		Screen breakaway distance	Millimeter	?			Automatic	
0220		Squeegee applied pressure	Lbs/sq.in per linear inch	1-10 psi/in. of squeegee			Automatic	
0220		Squeegee hardness	Durometer	60-75			Automatic	
0220		Substrate to screen distance	Millimeter	30-40			Automatic	
0220		Number of squeegee passes	Unitless	1, 2, or 3			Automatic	
0220		Particle size material properties	Microns	10	X bar-R	Manual	Automatic	
0220		Viscosity material properties	Centipoise	200,000	X bar-R	Manual	Automatic	
0220		Minimum layer thickness	Millimeter	.4			Automatic	
0220		Maximum layer thickness	Millimeter	2			Automatic	
0220		Emulsion thickness on screen	Millimeter	2-3			Automatic	

0220		Screen weave angle to substrate	Angular degrees	22, 45, or 90			Automatic	
0220		Substrate registration to screen	X-millimtr, Y-millimtr	+/-.5			Automatic	
0220		Screening defects	N/A	N/A	NP		Automatic	
0230	DRY CIRCUITRY	Environment	$String$	Oven, IR lamps, etc.				
0230		Drying temperature	Degrees C	180				
0230		Drying time	Minute	5-15				
0230		Drying wavelength (IR)	Micron	>3				
0230		Min/max layer thick	Millimeter	.5-2				
0240	FIRE CIRCUITRY	Environment	$String$	Oven, furnace, etc.				
0240		Temperature profile	Time vs. Degrees C	5 min. @ 300 C, etc.				0240
0240	Min/max layer thick	Millimeter	.3-1.4					
0250	INSPECT CIRCUITRY	Conductor resistivity	MilliOhms/Sq. in.	3	X bar-R	Manual		
0250		Wire pull strength (1 MIL Gold)	Grams	5	X bar-R	Manual		
0250	(Repeat Above 4 Operations For	Additional Layers As Required)	41lbs.	31lbs. after aging				
0260	SCREEN DIELECTRIC LAYER	Screen mesh	Wires/inch	325			Automatic	
0260		Screen tension	?	57-73			Automatic	
0260		Screen breakaway distance	Millimeters	?			Automatic	
0260		Squeegee applied pressure	Lbs/sq.in per linear inch	1-10 psi/in. of squeegee			Automatic	
0260		Squeegee deposition velocity	Inches/second	2-6			Automatic	
0260		Squeegee hardness	Durometers	60-75			Automatic	
0260		Substrate to screen distance	Millimeters	40-60			Automatic	
0260		Number of squeegee passes	Unitless	1, 2, or 3			Automatic	
0260		Solids content material properties	%	70	X bar-R	Manual	Automatic	
0260		Material viscosity	Centipoise	70,000-300,000	X bar-R	Manual	Automatic	
0260		Minimum layer thickness	Mil	1			Automatic	
0260		Maximum layer thicknes	Mils	2			Automatic	

0260		Emulsion thickness on screen	Mils	.8			Automatic	
0260		Screen weave angle to substrate	Angular degrees	45			Automatic	
0260		Substrate registration to screen	X-mils, Y-mils	+/-.5			Automatic	
0270	DRY DIELECTRIC LAYER	Environment	$Strings$	Oven, IR lamps, etc.			Batch	
0270		Drying temperature	Degrees C	180			Batch	
0270		Drying time	Minutes	5-15			Batch	
0270		Drying wavelength (IR)	Microns	>3			Batch	
0280	FIRE DIELECTRIC LAYER	Environment	$String$	Oven, furnace,etc.				
0280		Temperature profile	Time vs Degrees C	5 min. @ 300 C, etc.				
0290	INSPECT DIELECTRIC LAYER	Crossover capacitance	PF/IN2/2MIL	4000	X bar-R	Manual		
0290		Dielectric breakdown	Volts/MIL	500MIN	X bar-R	Manual		
0290	(Repeat Above 4 Operations For	Each Additional Circuit Layer)						
0300	APPLY EPOXY	?	?	?				
0310	ATTACH RESISTOR CHIPS	?	?	?				MIL-STD-883,METHOD 2017.7
0310								MIL-STD-883, Method 5011
0310								MIL-STD-883,METHOD 2019.4
0320	OVEN CURE	?	?	?				
0330	WIRE BOND RESISTORS	Bond height	Z-mils	10			Automatic	MIL-STD-883,METHOD 2011.5
0330		Bonding force- first & second bond	Grams	10			Automatic	MIL-STD-883,METHOD 2011.5
0330		Bonding power	Microinchess	0-250			Automatic	MIL-STD-883,METHOD 2023.3
0330		Bonding time	Milliseconds	100			Automatic	MIL-STD-883,METHOD 5003
0330		Location of first bond	X-mils, Y-mils	?			Automatic	

0330		Location of second bond	X-mils, Y-mils, Z-mils	?			Automatic	
0330		Loop height, loop length	Mils/mils	6-20/10-200			Automatic	
0330		Tail length	Mils	2			Automatic	
0330		Wire diameter	Mils	1			Automatic	
0330		Wire material	$String$	Gold or Aluminum			Automatic	
0330		Wire doping material/percentage	$String$	Silicon/1.0%			Automatic	
0330		Wire material purity	Percent purity	99.999			Automatic	
0330		Wire elongation	Percent	3-7			Automatic	
0330		Wire tensile strength	Grams	15			Automatic	
0330		Time from last cleaning operation	Hours, date (yymmdd)	16, 910322			Automatic	
0330		Bond signature	?	?			Automatic	
0340	TRIM RESISTORS, ACITVE	Name of component to be trimmed	$String$	R17			Automatic	
0340	(Using Laser Process)	Location of start of trim	X-mils, Y-mils	xx.xxx, yy.yyy			Automatic	
0340		Coordinate data for path of trim	X-mils, Y-mils	xx.xxx, yy.yyy			Automatic	
0340		Pulse repetition rate	Kilohertz	35			Automatic	
0340		Resistor trim geometry	$String$	"L", :J", or Plunge Cut			Automatic	
0340		Type of laser use in trimming	$String$	YAG, Co2, etc.			Automatic	
0340		Laser power, maximum	Watts	15			Automatic	
0340		Laser power, minimum	Watts	12			Automatic	
0340		Spot size	Microns	0.002			Automatic	
0340		Target reistance	Ohms	1000			Automatic	
0340		Target resistance tolerance	Ohms	plus/minus 0.1			Automatic	
0340		Trim speed, course	Mils/second	n/a			Automatic	
0340		Trim speed, fine	Mil/second	n/a			Automatic	
0340		Trim kerf width	Mils	0.002 (spot size)			Automatic	
0340		Trim width, minimum	Mils	0.010			Automatic	
0340		Parameter to be measured	$String$	3.5 vdc at TP1			Automatic	

0340		Tolerance of parameter measured	$String$	plus/minus 0.02 vdc			Automatic	
0340		Operating conditions for trim	$String$	Vcc=5.0,@ minus 55 C			Automatic	
0350	INSPECT	?	?	?				
0360	TO NEXT ASSEMBLY OR STORES	n/a	n/a	n/a			n/a	n/a
	GENERIC THICK FILM ASSEMBLY PROCESS FLOW							
0400	PLASMA CLEAN	Operating frequency	MHz	13				
0400		Operating pressure	Microns (Hg)	5				
0400		Power, RF	Watts	100				
0400		Cleaning time	Minutes 10					
0400		Gases for plasma	$String$	Oxygen, Argon, etc.				
0400		Partial pressure of atmosphere	Percent	10% Oxygen, 90% Argon				
0400		Number of units to be cleaned (load)	Unitless	1-50				
0410	SCREEN CONDUCTIVE EPOXY	Screen mesh	Wire/inch	200				MIL-STD-883,METHOD 2017.7
0410		Screen tension	?	?				MIL-STD-883,METHOD 2019.4
0410		Screen breakaway distance	Mils	?				MIL-STD-883,METHOD 5011
0410		Squeegee applied pressure	Lbs/sq.in per linear inch	1-10 psi/in. of squeegee				
0410		Squeegee deposition velocity	Inches/second	2-6				
0410		Squeegee hardness	Durometers	60-70				
0410		Substrate to screen distance	Mils	30				
0410		Number of squeegee passes	Unitless	1, 2, or 3				
0410		Emulsion thickness on screen	Mils	.8				
0410		Screen weave angle to substrate	Angular degrees	45				
0410		Substrate registration to screen	X-mils, Y-mils	+/-2				
0410		Viscosity material properties	Rotovisco units	20				

0410		Volume resistivity material properties	OHM-CM	2.5x10-4 MAX				
0410		Minimum layer thickness	Mils	.0025				
0410		Maximum layer thickness	Mils	.0035				
0430	ATTACH ACTIVE COMPONETS		N/A	N/A				MIL-STD-883,METHOD 2017.7
0430								MIL-STD-883,METHOD 2019.4
0430								MIL-STD-883, Method 5011
0440	OVEN CURE	Oven temp	C	150				MIL-STD-883, Method 2017.7
0440		Cure time	Hrs	2				MIL-STD-883, Method 2019.4
0440								MIL-STD-883, Method 5011
0450	APPLY NONCONDUCTIVE EPOXY	?	?	?				MIL-STD-883, Method 2017.7
0450	(Spot dispensing method)							MIL-STD-883, Method 2019.4
0450								MIL-STD-883, Method 5011
0470	ATTACH PASSIVE COMPONENTS		N/A	N/A				MIL-STD-883, Method 2017.7
0470								MIL-STD-883, Method 2019.4
0470								MIL-STD-883, Method 5011
0480	OVEN CURE	Oven temp	C	150				
0480		Cure time	Hrs	2				
0490	WIRE BOND, THERMOSONIC	Bond height	Z-mils	10				MIL-STD-883, Method 2011.5
0490		Bonding force - first & second bond	Grams	20-500				MIL-STD-883, Method 2017.5
0490		Ponding temperature - capillary	Degrees centigrade	20				MIL-STD-883, Method 2023.3

0490		Bonding temperature - substrate	Degrees Centigrade	150-200				MIL-STD-883, Method 5003
0490		Bonding time - first & second bond	Milliseconds	1-999				
0490		Bonding power - first & second bond	Watts	First 1.3, second 1.3				
0490		Ball size	Mills	0.7				
0490		Location of first bond (ball)	X-mills, Y-mills	?				
0490		Location of second bond (stitch)	X-mills, Y-mills, Z-mills	?				
0490		Loop height, loop length	Mils/mils	6-20/10-200				
0490		Wire diameter	Mils	1-2				
0490		Wire tensile strength	Grams	15				
0490		Wire material	$String$	Gold				
0490		Wire material purity	Percent purity	99.999				
0490		Wiring doping material/percentage	$String$	Silicone/1.0%				
0490		Wire elongation	Percent	3-7				
0490		Wire tension in bonding machine	Grams	10				
0490		Time from last cleaning operation	Hours, date (yymmdd)	16, 910322				
0500	WIRE BOND, ULTRASONIC	Bond height	Z-mils	10				MIL-STD-883, Method 2011.5
0500	(Die to substrate)	Bonding force - first & second bond	Grams	10				MIL-STD-883, Method 2017.5
0500		Bonding power	Microinches	0-250				MIL-STD-883, Method 2023.3
0500		Bonding time	Milliseconds	100				MIL-STD-883, Method 5003
0500		Location of first bond	X-mils, Y-mils	?				
0500		Location of second bond	X-mills, Y-mills, Z-mills	?				
0500		Loop height, loop length	Mils/mils	6-20/10-200				
0500		Tail length	Mills	2				
0500		Wire diameter	Mills	1				
0500		Wire material	$String$	Gold or Aluminum				

0500		Wire doping material/percentage	$String$	Silicon/1.0%				
0500		Wire material purity	Percent purity	99.999				
0500		Wire elongation	Percent	3-7				
0500		Wire tensile strength	Grams	15				
0500		Time from last cleaning operation	Hours, date (yymmdd)	16, 910322				
0500		Bond signature	?	?				
0510	WIRE BOND PULL TEST	Location of first bond	X-mils, Y-mils, Z-mils	?				MIL-STD_883, Method 2011.5
0510		Location of second bond	X-mils, Y-mils, Z-mils	?				MIL-STD-883, Method 2023.3
0510		Location of hook	X-mils, Y-mils, Z-mils	?				MIL-STD-883, Method 5003
0510		Hook size relative to wire size	Ratio	2:1				
0510		Applied force	Grams	Wire size dependent				
0510		Angle of pull from normal	Degrees	0				
0510		Precondition temperature	Degrees Centigrade	300				
0510		Precondition time	Hours	1				
0510		Wire diameter	Mills	1				
0510		Wire material	$String$	Gold, Aluminum				
0510		Sample size	Unitless	20 out of 100				
0510		Failure criteria, min., ave., sigma	Grams	1.2, 2, and 3				
0520	CLEAN HEADER	Solvent name	$String$	Alcohol				
0520		Solvent identification data	$String$	Mfgrs. name, part number				
0520		Solvent cleaning time	Minutes	1				
0520		Solvent cleaning temperature	Degrees Centigrade	105 +/-5				
0520		Drying time	Minutes	1				
0520		Drying temperature	Degrees Centigrade	105 +/-5				
0530	MARK HEADER	?	?	?				
0540	CURE MARKING	?	?	?				

0550	MOUNT SUBSTRATE TO HEADER	?	?	?				
0560	OVEN CURE	Oven temp	C	150				
0560		Cure time	Hrs	2				
0570	WIRE BOND	Bond height	Z-mills	10				
0570	(Substrate to header)	Bonding force - first & second bond	Grams	20-500				
0570		Bonding temperature - capillary	Degrees Centigrade	20				
0570		Bonding temperature - substrate	Degrees Centigrade	150-200				
0570		Bonding time - first & second bond	Milliseconds	1-999				
0570		Bonding power - first & second bond	Watts	First 1.3, second 1.3				
0570		Ball size	Mills	2-4				
0570		Location of first bond (ball)	X-mills, Y-mills	?				
0570		Location of second bond (stitch)	X-mills, Y-mills, Z-mills	?				
0570		Loop height, loop length	Mills/mills	6-20/10-200				
0570		Wire diameter	Mills	1-2				
0570		Wire tensile strength	Grams	15				
0570		Wire material	$String$	Gold				
0570		Wire material purity	Percent purity	99.999				
0570		Wiring doping material/percentage	$String$	Silicone/1.0%				
0570		Wire elongation	Percent	3-7				
0570		Wire tension in bonding machine	Grams	10				
0570		Time from last cleaning operation	Hours, date (yymmdd)	16, 910322				
0580	WIRE BOND PULL TEST	Location of first bond	X-mills, Y-mills, Z-mills	?				
0580		Location of second bond	X-mills, Y-mills, Z-mills	?				
0580		Location of hook	X-mills, Y-mills, Z-mills	?				
0580		Hook size relative to wire size	Ratio	2:1				
0580		Applied force	Grams	3-20 (1 mil wire)				

0580		Angle of pull from normal	Degrees	0				
0580		Precondition temperature	Degrees Centigrade	300				
0580		Precondition time	Hours	1				
0580		Wire diameter	Mills	1				
0580		Wire material	$String$	Gold, Aluminum				
0580		Sample size	Unitless	20 out of 100				
0580		Failure criteria, min., ave., sigma	Grams	1.2, 2, and 3				
0590	FUNCTIONAL ELECTRICAL TEST	Test interface adapter	$String$	Part number identifier				MIL-STD-883, Methods 3001.3015
0590		Test procedure	$String$	Part number identifier				MIL-STD-883, Methods 4001-4007
0590		Date of test	Date (yymmdd)	911204				MIL-STD-883, Methods 5001-5010
0590		Electrical parameters	?	?				
0600	PRE-CAP VISUAL INSPECTION	?	?	?				
0610	CLEAN COVER	Solvent name	$String$	Alcohol				
0610		Solvent identification data	$String$	Mfgrs. name, part number				
0610		Solvent cleaning time	Minutes	1				
0610		Solvent cleaning temperature	Degrees Centigrade	105 +/-5				
0610		Drying time	Minutes	1				
0610		Drying temperature	Degrees Centigrade	105 +/-5				
0620	TACK COVER IN PLACE	?	?	?				
0630	BAKE-24 HR. NITROGEN	Oven temp	C	150				
0640	BAKE-24 HR. VACUUM	Oven temp	C	150				
0650	SEAL COVER	Ambient environment	Percent gas composition	90% N, 10% He				
0650	(parallel seam weld process)	Environmental moisture level	PPM water vapor	100				
0650		Pulse repetition time	Milliseconds	80-100				
0650		Pulse width (duration)	Milliseconds	60				

0650		Table speed	Inches/minute	1-2				
0650		Weld current	Amperes	360 +/- 20				
0650		Weld force	Grams	800				
0650		Material thickness at weld edge	Mills	0.012				
0650		Material to be welded	$String$	Kovar				
0660	FINE LEAK TEST	Bomb time/pressure	Hrs/PSIG	4/30				
0660		Leak rate	ATM-CC/SEC	5X10-8 MAX				
0670	GROSS LEAK TEST	Bomb time/pressure	Hrs/PSIG	10/30				
0680	MARK PACKAGE	Alpha-numeric and bar code images	N/A	N/A				
0680		Marking locations						
0680		Legibility						
0690	CURE MARKING	Solvent resistance	N/A	N/A				
0700	FUNCTIONAL ELECTRICAL TEST	Test interface adapter	$String$	Part number identifier				MIL-STD-883, Methods 3001-3015
0700		Test procedure	$String$	Part number identifier				MIL-STD-883, Methods 4001-4007
0700		Date of test	Date (yymmdd)	911204				MIL-STD-883, Methods 5001-5010
0700		Electrical parameters	Ohms,volts,amps,time,etc.	N/A				
0710	BURN-IN	Test chamber temperature	C	125				MIL-STD-883, Method 1015.6
0710		Duration at temperature	Hrs	168				MIL-STD-883, Method 5004.7
0710		Functional test parameters	N/A	N/A				
0720	FUNCTIONAL ELECTRICAL TEST	Test interface adapter	$String$	Part number identifier				MIL-STD-883, Methods 3001-3015
0720		Test procedure	$String$	Part number identifier				MIL-STD-883, Methods 4001-4007
0720		Date of test	Date (yymmdd)	911204				MIL-STD-883, Methods 5001-5010
0720		Electrical parameters	Ohms,volts,amps,time,etc.	N/A				

0730	STABILIZATION BAKE	Environment	$String$	Nitrogen				MIL-STD-883, Method 1008.2
0730		Temperature	Degrees Centigrade	150				MIL-STD-883, Method 1011.9
0730		Time	Hours	24				
0740	TEMPERATURE CYCLE	Environment	$String$	Nitrogen				MIL-STD-883, Method 1010.5
0740		Cycles	Unitless	10				MIL-STD-883, Method 1011.9
0740		Temperature	Degrees Centigrade/step	minus 65, plus 125				
0740		Time at each temperature cycle	Minutes	10,10				
0740		Transfer time	Seconds	6				
0750	PHYSICAL STRESS TEST	Force axis	Direction	Y<sub>1				MIL-STD-883, Method 2001.2
0750	(Using centrifuge method)	Force magnitude	G's	5000				
0750		Time subjected to force	Minutes	1				
0760	FINE LEAK BOMB	Ambient pressure vessel	Pounds/square inch	30-60				
0760	(He tracer gas method)	Time under pressure	Minutes	120				
0760		Internal volume of package	Cubic centimeters	1				
0770	FINE LEAK TEST	Dwell time, pressure rel. to test	Minutes	160				
0780	GROSS LEAK BOMB	Flouracarbon type	$String$					
0790	GROSS LEAK TEST	Flouracarbon temperature	Degrees Centigrade	125 +/-5				
0790		Immersion time	Seconds	30				
0800	Pind test	?	?	?				MIL-STD-883, Method 2020.6
0810	INSPECT	?	?	?				
0820	PACKAGE & LABEL FOR SHIPPING	Prepare tracibility documents	N/A	N/A				

Hybrid Microcircuit Assembly
Manufacturing Process Parameters
Data List

4.0 Multi-chip module manufacturing process parameters

As the multichip module (MCM) strives to become the electronics industry's next generation hybrid microcircuit, manufacturing companies are busy seeking out the best materials and processes available to build the powerful, high speed MCM's. Three (3)-mil line and space technology increases interconnect density, improves performance and reliability, and keeps costs under control, all using existing hybrid methods. The 3-mil technology is very compatible with green tape processes because it allows the use of highly conductive precious metals (in this case, gold). Green tape is made of a slurry combining ceramic fillers with a glass matrix to form a green (unfired) tape. This tape can be cut to different lengths and stacked to form the multilayer hybrid. Using a green tape system to laminate a dielectric to a ceramic substrate is similar to producing a multilayer printed circuit board only in a thick film format. The following is a list of processing parameters used for MCM's. An attempt has been made to keep the list generic so as it does not represent anyone manufacturers processing ways.

GENERIC, MULTI-CHIP ASSEMBLY PROCESS FLOW

OPERATION #	PROCESS DESCRIPTION	PROPERTY	UNITS OF MEASURE	TYPICAL VALUE\RANGE	SPC FORMAT	DATA	PROCESS TYPE	CONTROLLING DOCUMENT
4400	PLASMA CLEAN	Operating frequency	MHz	13				
4400		Operating presure	Microns (Hg)	5				
4400		Power, RF	Watts	100				
4400		Cleaning time	Minutes	10				
4400		Gases for plasma	$String$	Oxygen, Argon, etc.				
4400		Partial pressure of atmosphere	Percent	10% Oxygen, 90% Argon				
4400		Number of units to be cleaned (load)	Unitless	?				
4410	SCREEN CONDUCTIVE EPOXY	Screen mesh	Wire/inch	?				MIL-STD-883,METHOD 2017.7
4410		Screen tension	?	?				MIL-STD-883,METHOD 2019.4
4410		Screen breakaway distance	Mils	?				MIL-STD-883,METHOD 5011
4410		Squeegee applied pressure	Lbs/sq.in \ linear in.	1-10 psi/in. of squeegee				
4410		Squeegee deposition velocity	Inches/second	2-6				
4410		Squeegee hardness	Durometers	?				
4410		Substrate to screen distance	Mils	?				
4410		Number of squeegee passes	Unitless	1, 2, or 3				
4410		Material properites	?	?				
4410		Material properties						
4410		Minimum layer thickness	Mils	?				
4410		Maximum layer thickness	Mils	?				
4410		Emulsion thickness on screen	Mils	2-3				
4410		Screen weave angle to substrate	Angular degrees	22, 45, or 90				
4410		Substrate registration to screen	X-mils, Y-mils	?				
4420	CURE EPOXY	?	?	?				

4430	ATTACH ACTIVE COMPONETS	?	?	?				MIL-STD-883,METHOD 2017.7
4430								MIL-STD-883,METHOD 2019.4
4430								MIL-STD-883,METHOD 5011
4440	OVEN CURE	?	?	?				MIL-STD-883,METHOD 2017.7
4440								MIL-STD-883,METHOD 2019.4
4440								MIL-STD-883, METHOD 5011
4450	APPLY NONCONDUCTIVE EPOXY	?	?	?				MIL-STD,883 METHOD 2017.7
4450	(Spot dispensing method)							MIL-STD-883,METHOD 2019.4
4450								MIL-STD-883, METHOD 5011
4460	CURE EPOXY	?	?	?				
4470	ATTACH PASSIVE COMPONETS	?	?	?				MIL-STD-883,METHOD 2017.7
4470								MIL-STD-883,METHOD 2019.4
4470								MIL-STD-883,METHOD 5011
4480	OVEN CURE	?	?	?				
4490	WIRE BOND, THERMOSONIC	Bond height	Z-mils	10				MIL-STD-883,METHOD 2011.5
4490		Bonding force-first & second bond	Grams	20-500				MIL-STD-883-METHOD 2017.5
4490		Bonding temperature - capillary	Degrees Centigrade	20				MIL-STD-883,METHOD 2017.5
4490		Bonding temperature- substrate	Degrees Centigrade	150-200				MIL-STD-883,METHOD 2023.3
4490		Bonding time-first & second bond	Milliseconds	1-999				
4490		Bonding power- first & second bond	Watts	First 1.3,Second 1.3 watt				
4490		Ball size	Mills	0.7				
4490		Location of first bond (ball)	X-mils, Y-mils, Z-mils	?				
4490		Location of second bond (stitch)	X-mils, Y-mils, Z-mils	?				
4490		Loop height, loop length	Mils/Mils	6-20/10-200				
4490		W're diameter	Mils	1-2				

4490		Wire tensile strength	Grams	15				
4490		Wire material	$String$	Gold				
4490		Wire material purity	Percent purity	99.999				
4490		Wire doping material/percent	$String$	Silicone/1.0%				
4490		Wire elongation	Percent	3-7				
4490		Wire tension in bonding machine	Grams	10				
4490		Time from last cleaning operation	Hours, date (yymmdd)	16, 910322				
4500	WIRE BOND, ULTRASONIC	Bond height	Z-mils	10				MIL-STD-883,METHOD 2011.5
4500	(Die to substrate)	Bonding force - first & second bond	Grams	10				MIL-STD-883,METHOD 2017.5
4500		Bonding power	Microinches	0-250				MIL-STD-883,METHOD 2023.3
4500		Bonding time	Milliseconds	100				MIL-STD-883,METHOD 5003
4500		Location of first bond	X-mils, Y-mils	?				
4500		Location of second bond	X-mils, Y-mils, Z-mils	?				
4500		Loop height, loop length	Mils/mils	6-20/10-200				
4500		Tail length	Mils	2				
4500		Wire diameter	Mils	1				
4500		Wire material	$String$	Gold or aluminum				
4500		Wire doping material/percentage	$String$	Silicon/1.0%				
4500		Wire material purity	Percent purity	99.999				
4500		Wire elongation	Percent	3-7				
4500		Wire tensile strength	Grams	15				
4500		Time from last cleaning operation	Hours, date (yymmdd)	16, 910322				
4500		Bond signature	?	?				
4510	WIRE BOND PULL TEST	Location of first bond	X-mils, Y-mils, Z-mils	?				MIL-STD-883,METHOD 2011.5
4510		Location of second bond	X-mils, Y-mils, Z-mils	?				MIL-STD-883,METHOD 2023.3
4510		Location of hook	X-mils, Y-mils, Z-mils	?				MIL-STD-883,METHOD 5003

4510		Hook size relative to wire size	Ratio	2:1				
4510		Applied force	Grams	3-20 (1 mil wire)				
4510		Angle of pull from normal	Degrees	0				
4510		Precondition temperature	Degree Centigrade	300				
4510		Precondition time	Hours	1				
4510		Wire diameter	Mils	1				
4510		Wire material	$String$	Gold, Aluminum				
4510		Sample size	Unitless	20 out of 100				
4510		Failure criteria, min.,ave.,sigma	Grams	1.2, 2, and 3				
4520	CLEAN HEADER	Solvent name	$String$	Alcohol				
4520		Solvent identification data	$String$	Mfgrs. name, partnumber				
4520		Solvent cleaning time	Minutes	1.0				
4520		Solvent cleaning temperature	Degrees Centigrade	105 +/- 5				
4520		Drying time	Minutes	1.0				
4520		Drying temperature	Degrees Centigrade	105 +/-5				
4530	MARK HEADER	?	?	?				
4540	CURE MARKING	?	?	?				
4550	MOUNT SUBSTRATE TO HEADER	?	?	?				
4560	OVEN CURE	?	?	?				
4570	WIRE BOND	Bond height	Z-mils	10				
4570	(Substrate to header)	Bonding force-first and second bond	Grams	20-500				
4570		Bonding temperature - capillary	Degrees Centigrade	20				
4570		Bonding temperature - substrate	Degrees Centigrade	150-200				
4570		Bonding time - first and second bond	Milliseconds	1-999				
4570		Bonding power- first and second bond	Watts	First 1.3,Second 1.3 watt				
4570		Ball size	Mills	0.7				

4570		Location of first bond (ball)	X-mils, Y-mils	?				
4570		Location of second bond (stitch)	X-mils, Y-mils, Z-mils	?				
4570		Loop height, loop length	Mils/mils	6-20/10-200				
4570		Wire diameter	Mils	1-2				
4570		Wire tensile strength	Grams	15				
4570		Wire material	$String$	Gold				
4570		Wire material purity	Percent purity	99.999				
4570		Wire doping material/percentage	$String$	Silicone/1.0%				
4570		Wire elongation	Percent	3-7				
4570		Wire tension in bonding machine	Grams	10				
4570		Time from last cleaning operation	Hours, date (yymmdd)	16, 910322				
4580	WIRE BOND PULL TEST	Location of first bond	X-mils, Y-mils, Z-mils	?				
4580		Location of second bond	X-mils, Y-mils, Z-mils	?				
4580		Location of hook	X-mils, Y-mils, Z-mils	?				
4580		Hook size relative to wire size	Ratio	2:1				
4580		Applied force	Grams	?				
4580		Angle of pull from normal	Degrees	0				
4580		Precondition temperature	Degree Centigrade	300				
4580		Precondition time	Hours	1				
4580		Wire diameter	Mils	1				
4580		Wire material	$String$	Gold, Aluminum				
4580		Sample size	Unitless	20 out of 100				
4580		Failure criteria, min., ave., sigma	Grams	1.2, 2, and 3				
4590	FUNCTIONAL ELECTRICAL TEST	Test interface adapter	$String$	Part number identifier				MIL-STD-883,METHODS 3001-3015
4590		Test procedure	$String$	Part number identifier				MIL-STD-883,METHODS 4001-4007

4590		Date of test	Date (yymmdd)	911204				MIL-STD-883, METHODS 5001-5010
4590		Electrical parameters	?	?				
4590								MIL-STD-883, METHODS 5001-5010
4600	PRE-CAP VISUAL INSPECTION	?	?	?				
4610	CLEAN COVER	Solvent name	$String$	Alcohol				
4610		Solvent identification data	$String$	Mfgrs. name, part number				
4610		Solvent cleaning time	Minutes	1.0				
4610		Solvent cleaning temperature	Degrees Centigrade	105 +/- 5				
4610		Drying time	Minutes	1.0				
4610		Drying temperature	Degrees Centigrade	105 +/- 5				
4620	TACK COVER IN PLACE	?	?	?				
4630	BAKE - 24 HR. NITROGEN	?	?	?				
4640	BAKE - 24 HR. VACUUM	?	?	?				
4650	SEAL COVER	Ambient environment	Percent gas composition	90 % N 10% He				
4650	(Parallel seam weld process)	Environmental moisture level	Parts/million water vapor	100				
4650		Pulse repetition time	Milliseconds	80-100				
4650		Pulse width (duration)	Milliseconds	60				
4650		Table speed	Inches/minute	1-2				
4650		Weld current	Amperes	360 +/- 20				
4650		Weld force	Grams	800				
4650		Material thickness at weld edge	Mils	0.012				
4650		Material to be welded	$String$	Kovar				
4660	FINE LEAK TEST	Helium leak rate	?	PPM Oxygen				
4670	GROSS LEAK TEST	Sealer atmosphere	?	PPM moisture				
4680	MARK PACKAGE	Alpha-numeric & bar code images	?	?				
4680		Marking locations						

4680		Legibility						
4690	CURE MARKING	Solvent resistance	?	?				
4700	FUNCTIONAL ELECTRICAL TEST	Test interface adapter	$String$	Part number identifier				MIL-STD-883, METHODS 3001-3015
4700		Test procedure	$String$	Part number identifier				MIL-STD-883, METHODS 4001-4007
4700		Date of test	Date (yymmdd)	911204				MIL-STD-883, METHODS 5001-5010
4700		Electrical parameters	?	?				
4710	BURN-IN	Test chamber temperature	?	?				MIL-STD-883, METHOD 1015.6
4710		Duration at temperature	?	?				MIL-STD-883, METHOD 5004.7
4710		Functional test parameters	?	?				
4720	FUNCTIONAL ELECTRICAL TEST	Test interface adapter	$String$	Part number identifer				MIL-STD-883, 3001-3015
4720		Test procedure	$String$	Part number identifier				MIL-STD-883, METHODS 4001-4007
4720		Date of test	Date (yymmdd)	911204				MIL-STD-883, METHODS 5001-5010
4720		Electrical parameters	?	?				
4730	STABILIZATION BAKE	Environment	$String$	Nitrogen				MIL-STD-883, METHOD 1008.2
4730		Temperature	Degrees Centigrade	105				MIL-STD-5008.4
4730		Time	Hours	24				
4740	TEMPERATURE CYCLE	Environment	$String$	Nitrogen				MIL-STD-883, METHOD 1010.5
4740		Cycles	Unitless	10				MIL-STD-883, METHOD 1011.9
4740		Temperature	Degrees C/step	-65 +125				
4740		Time at each temperature cycle	Minutes	10,10				
4740		Transfer time	Seconds	6				
4750	MECH. CLEAN ROOM ATMOSPHERE	Lead length particle count	millimeter	+/- sub-micron particles				
4760	PHYSICAL STRESS TEST	Force axis	Direction	Y <sub> 1				MIL-STD-883,METHOD 2001.2
4760	(Using centrifuge method)	Force magnitude	G's	5000				
4760		Time subjected to force	Minutes	1				

4770	FINE LEAK BOMB	Ambient pressure vesel pressure	Pounds/square inch	30-60				
4770	(He tracer gas method)	Time under pressure	Minutes	120				
4770		Internal volume of package	Cubic Centimeters	1				
4780	FINE LEAK TEST	Dwell time, pressure rel. to test	Minutes	160				
4790	GROSS LEAK BOMB	Fluorocarbon type	$String$					
4790		Fluorocarbon temperature	Degrees Centigrade	125 +/- 5				
4790		Immersion time	Seconds	30				
4800	GROSS LEAK TEST	?	?	?				
4810	PIND TEST	?	Percent yield	?				MIL-STD-883, METHOD 2020.6
4820	INSPECT	?	?	?				
4830	PACKAGE & LABEL FOR SHIPPING	Prepare tracibility documents	n/a	n/a			n/a	n/a

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